**UNITED STATES CONTINUATION-IN-PART PATENT APPLICATION**

**FOR**

# HIGH TORQUE ROTATABLE PROGRESSIVE CAVITY DRIVE RODS AND CONNECTORS

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# HIGH TORQUE ROTATABLE PROGRESSIVE CAVITY DRIVE RODS AND CONNECTORS

## CROSS-REFERENCE TO PENDING APPLICATIONS

This application is a continuation-in-part of U.S. Patent Application No. 10/210,221 entitled "High Torque Rotatable Progressive Cavity Drive Rods and Connectors" filed August 1, 2002.

# HIGH TORQUE ROTATABLE PROGRESSIVE CAVITY DRIVE RODS AND CONNECTORS

## BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention relates to rotatable rods and connectors used with progressive cavity devices for pumping oil or other fluids out of wells. More specifically, the present invention relates to drive rods having novel pins and connectors specially and uniquely designed for high torque rotation and suited for use with progressive cavity pumps or motors.

2. Prior Art.

For over 100 years, sucker rods have been utilized to pump crude oil and other liquids out of wells. Sucker rods typically have threaded pins on each end that are screwed into connectors. Connectors attach to a sucker rod on either end. Sucker rods vary in length but typically have standard, common gauged threaded pins manufactured to API Standard II B specifications.

A string of sucker rods may extend several thousand feet into a well. They must, therefore be very strong. Because of this, they are typically made of metal. In addition, lighter sucker rods are typically included at the bottom of the string while the sucker rods at the top of the string are often heavier and stronger in order to support the string. The top of the sucker rod string is attached to a pump jack. The bottom of the string is attached to a pump. Pump jacks reciprocate the sucker rod string in an upward and downward motion and subjects the string to compression and tension forces. This reciprocating motion operates the pump located at the bottom of the well.

It is highly desirable that sucker rods do not become unscrewed and detach from the connectors between them. If this occurs, the pumping action halts. It is also difficult and labor

intensive to stop the pump jack and retrieve the portion of the sucker rod string in the bottom of the well. In order to prevent this, sucker rod pins and connectors have been designed so as not to come unscrewed when a reciprocating motion is applied. In order to minimize the risk of detachment, sucker rod pins have evolved into a three part structure. First, at the end of the pin is straight threading. This provides for maximum friction on the flanks of the threading. Just below the threading is an undercut, or stress relief. Finally, both the connectors and the sucker rods have shoulders designed to engage one another. The presence of the stress relief allows for greater friction between the engaged shoulders. The friction between the shoulders prevents the sucker rods and connectors from disengaging. The straight threading increases the ability of the sucker rod string to withstand the stress of the reciprocating motion.

Recent advances in pump technology have made it desirable to utilize progressive cavity ("PC") pumps in oil and water wells. PC pumps are well suited for very viscous liquids, such as crude oil and for liquids having solids, such as sand, therein They are also capable of operating under very high pressure. Examples of these pumps may be found as far back as U.S. Patent No. 1,892,217; U.S. Patent No. 2,085,115; and U.S. Patent No. 2,483,370 issued to Moineau. These PC pumps have fewer moving parts than other pumps typically used in wells. They are both sturdier and less likely to malfunction.

The same technology utilized in progressive cavity pumps may also be employed in progressive cavity motors.

Existing sucker rods are well suiting to withstand the stress of reciprocating tension and compression motion. However, standard sucker rods are not ideal for use with PC pumps or motors. PC pumps require a rotational motion instead of a reciprocating motion. However, they are not ideally suited to withstand high torque rotation.

It is, therefore, desirable to provide a drive rod and connector for progressive cavity pumps capable of withstanding high torque rotation.

It is also desirable to provide a pin for a drive rod and a connector that will resist rotation between the pin and connector once the pin has been fully threaded into the connector.

It is also known that rotatable movement of the threaded sucker rod pin in the connector will cause the pin to elongate, even after the pin is threaded into the connector.

It is, therefore, desirable to provide a connector for a high torque rotatable progressive cavity drive rod that includes an internal secondary stop to halt elongation of the pin.

## SUMMARY OF THE INVENTION

The rods and connectors of the present invention have frustoconical tapered, rather than straight, threading. In the existing art of sucker rods, tapered threading has generally been discouraged. When reciprocating motion is applied, it is typically easier to jar loose sucker rods having tapered threading. However, because the purpose of these sucker rods is to provide a superior rod string for use in high torque, rotational motion, tapered threading is actually preferred. The constant, high speed rotation ensures that the sucker rods and their connectors remain screwed together tightly.

Another reason current sucker rods strings are not suitable for use with PC pumps that require rotation is that the connectors are not well designed for this type of stress. Though well designed to tolerate the stresses of reciprocating motion, the walls of a connector are generally too thin to withstand high torque. When exposed to high rotational pressure, these connectors will break. Because the present invention provides for tapered threading on the pins of the sucker rods, the walls of the connectors are thicker. Connectors having thicker walls are capable of withstanding greater torsional stress.

To further facilitate transfer of the rotational motion between sucker rods and connectors, the undercut found on sucker rod pins is reduced in the present invention. The rotational motion of the string constantly tightens the pin within the connector, thereby reducing sucker rod's danger of disengagement. The need for the increased friction on the shoulders provided by an undercut is therefore eliminated. Furthermore, this additional threading provides for a greater surface area over which the rotational motion is transferred. This further enhances the sucker rod string's ability to withstand high torsional stress. The synergistic effect of tapered threading, thicker connectors, and reduction of the undercut provides rods and connectors having superior tolerance to rotational stress.

In the present invention, the pins of sucker rods are modified so that they may better withstand the stress of high torque up to 1,750 foot pounds.

It is therefore an object of the present invention to provide sucker rod strings capable of withstanding the stress of high torque rotation.

Once the pin has been fully threaded in the connector, continued rotational force of the pin in the connector causes elongation of the pin. Accordingly, it is desirable to reduce movement between the pin and connector once the pin has been fully threaded into the connector. Increased friction between the pins and connectors is provided by increasing the outside diameter of the conenctor and the shoulder of the pin. Increased friction between the pins and the connectors is provided by roughening the surfaces of the shoulder of the pin and roughening the surfaces of the shoulder of the connector.

Elongation of the pin once it has been fully threaded in the connector is also discouraged by a secondary internal stop within the connector. The internal stop is normally spaced from the end of the pin and will engage the pin if elongation continues past a desired point.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a diagrammatic illustration of a drive rod string and connector being utilized to drive a progressive cavity pump downhole in a well;

Figure 1A shows an enlarged portion of the drive rod string of Figure 1;

Figure 2 shows a side plan view of one end of a typical prior art sucker rod currently in use;

Figure 3 is a side plan view of the drive rod of the present invention;

Figure 4 is a cross sectional view of a drive rod connector of the present invention with secondary internal stop;

Figure 5 is a side view of the drive rod shown in Figure 3 threaded into the connector shown in Figure 4 partially cut-away for clarity; and

Figure 6 illustrates an outside perspective view of a connector shown apart from the pins of the connector.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is an improved drive rod and connector capable of high torque rotation. The key features of the present invention work together synergistically to improve the amount of rotational stress that a drive rod and connector can withstand. These improvements include drive rod pins having tapered threading and reduced undercut. This also results in strengthened connectors having a larger outer diameter and thicker sidewalls. The reduced undercut increases the surface area by which rotational motion may be transferred from a drive rod to a connector to a subsequent drive rod.

The present invention is especially useful for driving a progressive cavity pump or motor.

Drive rods are comprised of approximately three components: The first, the body, is a long, usually metal, shaft typically about 25 - 30 feet in length. The other two components are the pins located at each end of the shaft. The pins are threaded so that they may be screwed into connectors. One rod is screwed into the bottom of a connector while another is screwed into the top. This is repeated until the rod string is of the desired length. This can sometimes be several thousand feet and require numerous rods.

Recently, pumps known as progressive cavity pumps have been developed for use in pumping oil and other fluids out of wells. These pumps are especially suited for pumping thick viscous liquids such as crude oil. A relatively simple design makes them both sturdy and reliable. This has resulted in a need for a sucker rod better suited for rotational rather than reciprocating tension and compression motion.

Figure 1 illustrates a typical well arrangement having a progressive cavity pump wherein the present invention is employed. An oil well 10 has a PC pump 28 located at the bottom of it. At the

top of the well is a powered drive head 12. The drive head 12 is rotated by a motor. This results in rotation of the polished rod 14 which projects downward through a stuffing box 16. The stuffing box 16 creates a water proof seal such that pumped fluids will not exit through the top of stuffing box 16. Directly below the stuffing box is a flowline 18. Pumped oil or other fluid exits the well through this flowline. Below this is a tubing head 19 located directly above casing head 20. Those skilled in the art of well drilling will be familiar with tubing head 19 and casing head 20 as well as the casing 26 itself. The polished rod 14 is connected to the top end of drive rod string 22. Drive rods in the string are held together by connectors 24 as will be described.

Figure 1A shows an enlarged view of sucker rod string 22 and a connector 24 holding 2 rods 30 and 32 together. For simplicity, this diagram shows use of only 2 sucker rods. Those skilled in the art will appreciate that in practically all wells, the rod string is comprised of several rods and connectors. The pins of drive rods 30 and 32 are not seen in Figure 1 or Figure 1A. This is because the pins themselves have been screwed into the connector and are not visible.

It will be recognized that various other arrangements are possible within the spirit and scope of this invention.

Figure 2 shows a pin of a typical rod common in the art prior to introduction of the present invention. Sucker rod pin 36 is comprised of a cylindrical threaded portion 38 and an undercut portion 40. Cylindrical threaded portion 38 has a constant diameter and is sometimes known in the art as straight threading. Undercut 40 has a diameter slightly less than that of threaded portion 38 and extends to shoulder 42. Shoulder 42 has a greater diameter than the other portions of the shaft. It has an engaging portion 44 that comes in firm contact with a complimentary shoulder on the connector (to be described below).

The friction created by the contact between engaging portion 44 or shoulder 42 and the shoulder of a connector discourages the unscrewing of a sucker rod from a connector. The presence of an undercut 40 allows threaded portion 38 to be screwed into a connector more tightly, thus increasing the static friction created by the shoulders. Without undercut 40, the connector and sucker rod are connected more loosely and are more likely to unscrew. Therefore, the present art teaches away from reducing or eliminating undercut 40. Underneath shoulder 42 is a square bolt portion of 46. This is the portion of the shaft that is engaged by tools that tighten the sucker rods' connections to the connectors. A main body 48 of the sucker rod is substantially cylindrical and extends the length of the sucker rod. An identical pin, not shown, is located on the other end of the sucker rod main shaft 48.

Prior art connectors 24 are essentially elongated nuts having a bore and an interior threading complimentary to threaded portions 38. The bore has a length that is at least slightly greater than the length of two pins 36. This prevents pins 36 from contacting each other and allows the rods to be screwed into the connectors more tightly.

Figure 3 shows a drive rod of the present invention from a similar angle as the prior art in Figure 2. It shows modified pin 60 having a threaded portion 62. As clearly shown in Figure 3, threaded portion 62 is slightly tapered and frustoconical. In a preferred embodiment, the threaded portion tapers slightly inward at about 3.5°. In this particular embodiment, there is a very narrow undercut 64. This particular embodiment shows slight undercut 64 in order to illustrate that it is possible in the present invention to utilize an undercut. It is desirable to have undercut 64 as small as possible. It is however substantially easier to machine a pin having a slight undercut than machining a pin having no undercut at all. Tapered threading offers a variety of advantages.

Threaded tapering offers better balance of strength from the connection, easier stabbing during make-up, quicker release on break-out and greater ease of re-working.

In the past, the art has taught away from such tapering because they are easier to pull apart and become disconnected. However, when the sucker rods are rotated, the tapered threading and the pin tightens its engagement to the connector resulting in a very strong connection. Furthermore, tapering causes the pin 60 to be placed in radial and circumferential compression and the socket to be placed in radial compression and circumferential tension. This radial tension allows rotational movement to be transferred from a rod to a connector to a subsequent rod in a smoother fashion. This increases the amount of torque and rotational stress that the sucker rod string may be subjected to without failure.

A shoulder 66 has a greater diameter than the other portions of the shaft. It has an engaging portion or surface 68 that comes in contact with complimentary shoulder on the connector.

In the present invention, rotational motion may be transferred not only by the shoulder 66, as in traditional sucker rods, but also by the entire pin itself. This increase in surface area over which torque is transferred reduces overall stress on the pin and drive rod as a whole. Those skilled in the art will appreciate that by utilizing the entire pin as well as the shoulder to transfer rotational movement, overall strain on the drive rod is reduced. Typical one inch rod connections cannot withstand more than 1,100 foot pounds of torque. One inch drive rod connections according to the present invention, however, have been found to withstand up to 1,750 foot pounds of torque. This provides sturdier, more reliable, and faster withdrawal of oil or other fluids from a well.

Figure 4 shows a connector 70 of the present invention suitable for use with a drive rod disclosed in Figure 3. Connector 70 is essentially an elongated nut having a cylindrical outside wall

72 penetrated by bore 80. The bore 80 has tapered threading 74 complimentary to pin 60 in Figure 3. In this particular embodiment, a slight undercut 76 is included in bore 80 in order to accommodate the slight undercut 64 on pin 60 shown in Figure 3. As stated above, this undercut is unnecessary but the invention may be easier to machine in this fashion. In this particular embodiment, connector 70 is approximately 4 inches long. This is more than long enough to adequately accommodate two pins 60 which are each approximately 1.75 inches long. This allows the threading inside the connector 70 to tighten upon rotation of the sucker rods string. One of the advantages of the design of the present invention is that connector wall 72 is thicker than those of more traditional connectors without increase of the outside diameter. This allows connector 70 to withstand more torsional stress than a standard connector. The added thickness of wall 72 adds strength to the connector. In addition, the tapered threading allows the connector to transfer a rotational motion through both shoulder 82 and bore 80. As explained above, spreading the transfer of rotational force over a larger surface area allows the connector, like the pin, to withstand more force.

Additionally, connector 70 has a pair of opposed shoulders 82. Each shoulder 82 has a roughened surface which mates with surface 82 which is similarly roughened. This significantly increases the coefficient of friction. The mating of the roughened surfaces helps transfer rotational movement of the pin to the connector. The mating of the roughened surfaces also prevents the pin from further rotation once the surfaces mate with each other.

Finally, Figure 5 illustrates a side view with a connector 70 partially cut-away. The pin 60 has been threaded into and fully engaged with the connector 70. The connector 70 also includes an internal secondary stop 90 which has a diameter less than the diameter of the pins at their farthest

most end. When each of the pins 60 is threaded into the connector 70, the end of the pin is spaced slightly from the internal stop 90. In the event that the pin continues to rotate with respect to the connector 70, it has been found that it may cause the threaded portion of the pin to continue to elongate. In the event that the pin continues to elongate with further rotation, the internal stop 90 acts as a secondary, positive stop for the pin and restricts elongation past a certain permitted length. Accordingly, the mating of the shoulder of the pin with the shoulder of the connector acts as the initial stop for the pin. Additionally, the internal secondary stop 90 acts as a backup or secondary stop for rotation and elongation of the pin.

In one non-limiting example, the pin may be permitted to elongate 10/1000 of an inch before the end of the pin engages the internal secondary stop.

Figure 6 illustrates an outside perspective view of a connector 70 shown apart from the pins of the connector. The roughened surface of the shoulder 82 is visible on one end of the connector.

Although these modifications may not appear significant, those skilled in the art will appreciate that the present invention has unique mechanical properties not found in existing sucker rods. Modifications made to the pins and connectors allow at least 25% more torque to be safely supplied through a rod string. Those skilled in the art will appreciate that this significantly improves the use of progressive cavity pumps.

The present progressive cavity rod will provide greater torque values than existing sucker rod strings as may be observed from the following table:

| TYPICAL RECOMMENDED TORQUE VALUES FOR ROD STRING CONNECTORS<br>All torque values are in foot pounds | | |
|---|---|---|
| **Rod Size** | **Grade D (78)** | **PC Rod** |
| 1" | 1100 | 1,750* |
| 1-1/8" | 1500 | 2,000** |
| 1- 1/4" | 2100 | 2,500** |
| *Actual torque values from test data<br>**Projected torque values - actual tests in process | | |

Whereas, the present invention has been described in relation to the drawings attached hereto, it should be understood that other and further modifications, apart from those shown or suggested herein, may be made within the spirit and scope of this invention.